

SECTION 8A - INJECTION WELL PLUGGING & ABANDONMENT PROCEDURES

This section is provided to satisfy the requirements of 40 CFR 146.92.

8A.1 Description of Plugging Procedures

Upon completion of the project, or at the end of the life of the CCS #2 injection well, the well will be plugged and abandoned to meet all applicable requirements. The need to abandon the well prior to any injection (i.e. during construction) is also a possibility. The plug procedure and materials will be designed to prevent any unwanted fluid movement and to protect any USDWs. The well plugging procedure and design will be updated in the well plugging plan based on any new information gained during well construction and testing. The final plugging plan will be developed after collaboration and interaction with the UIC Program Director; however, to fulfill permit requirements, we propose the preliminary plan which follows.

8A.1.1 Abandonment during Construction

Abandonment during well construction, while sections of the wellbore are uncased could take place while: (1) drilling the surface hole (≤ 350 ft), (2) drilling intermediate hole ($\leq 5,300$ ft), or (3) drilling long-String hole ($\leq 7,500$ ft).

During each scenario, the drill string (drill collars, drill pipe, and drill bit) represents the most likely risk for losing and leaving equipment in the hole. Although unlikely, it is possible that logging tools, a core barrel, or other piece of equipment can get stuck and be left in the hole. Every attempt will be made to recover all portions of the string or other equipment prior to abandonment.

If equipment cannot be retrieved and must be abandoned in the wellbore, no unique plugging procedure should be required and the plugs will be placed as specified in the plugging plan. Plug placement will depend upon depth of the hole, the geology and the depth that the equipment was lost in the well. If the well has not penetrated or is not within 100 feet of the caprock, then typically plugging during construction would require placing plugs across any zones capable of producing fluid and at the previous casing shoe. A surface plug will be set and the well filled with drilling mud between the plugs. If the caprock has been penetrated when the well is judged to be lost, the well will be plugged using CO₂-resistant cement from TD to 1,000 feet above the caprock seal using the balanced plug method. This may require setting multiple plugs. If this occurs, each plug will be verified before moving to the next.

If a radioactive logging source is lost in the hole (e.g. a density and/ or neutron porosity logging source), current Nuclear Regulatory Commission (NRC) regulations will be followed. A 300-foot red cement plug will be placed immediately above the lost logging tool. An angled kick-plate will be placed above this plug to divert any subsequent drilling that may coincidentally enter this wellbore. Current NRC regulations require that the surface casing remain extended above the ground surface with an informative ground plate welded to the pipe. The plate includes information to identify what is in the hole. Depending upon where in the well the radioactive source is lost, plugging above the kick-plate will proceed as described above.

Plug Placement Method: The method for placing the plugs in CCS #2 will be the “Balanced Plug” method. This is a basic plug spotting process that is generally considered more efficient and is consistent with best industry practices.

8A.1.2 Abandonment after Injection

After injection has ceased, the well will be flushed with a kill weight brine fluid. A minimum of three tubing volumes will be injected without exceeding fracture pressure. Bottom hole pressure measurements will be made and the well will be logged to ensure mechanical integrity outside the casing prior to plugging. If a loss of mechanical integrity is discovered, it will be repaired using the squeeze cementing method prior to proceeding with the plugging operations. Detailed plugging procedure is provided in Section 8A.1.4 below. All casing in this well will be cemented to surface and will not be retrievable at abandonment. After injection, the injection tubing and packer will be removed. If the tubing and packer cannot be released, an electric line with tubing cutter will be used to cut off the tubing above the packer and the packer will be left in the well. After the tubing and packer are removed, the balanced-plug placement method will be used to plug the well. If the tubing has to be cut and the packer left in the well, the cement retainer method will be used for plugging the injection formation below the abandoned packer.

8A.1.3 Type and Quantity of Plugging Materials, Depth Intervals

The volume and depth of the plug or plugs will depend on the final geology and downhole conditions of the well as assessed during construction. Well cementing software (e.g. Schlumberger’s CemCade) will be used to model the plugging and aid in the plug design. The cements used for plugging will be tested in the lab prior to plug placement and both wet and dry samples of each plug will be collected during plugging to ensure quality of the plug.

All of the casing strings will be cut off at least 3 feet below the surface, below the plow line. A blanking plate with the required permit information will be welded to the top of the cutoff casing.

8A.1.4 Detailed Plugging and Abandonment Plan

8A.1.4.1 Notifications, Permits, and Inspections (Prior to Workover or Rig Movement).

Notifications, permits, and inspections are the same for plugging and abandonment during construction or post-injection. The procedure is:

- 1) Notify the regulatory agency at least 60 days prior to commencing plugging operations. (Note that this timeline will not apply for plugging and abandonment during well construction.) Provide updated plugging plan, if applicable. Ensure proper notifications have been given to all regulatory agencies for rig move.
- 2) Ensure that the plugging procedure has been reviewed and agreed upon by regulatory agency.
- 3) Ensure that the following steps are performed prior to well plugging:
 - a. The injection well is flushed with a buffer fluid;
 - b. The bottomhole reservoir pressure will be measured;

- c. A final external mechanical integrity test will be completed.
- d. Plugging procedure has been reviewed and agreed upon by regulatory agency.
- 4) Ensure in advance that a pre-site inspection has been performed and the rig company has visited the site and is capable of transporting rig, tanks & ancillary equipment to perform P&A operations. Notify all key third parties of expected work scope, and ensure third party contracts for work are in place prior to move in.
- 5) Have copies of all government permits prior to initiating operations and maintain on location at all times. Check to see if conditions of approval have been met.
- 6) Make sure partners (U.S. DOE, EPA and ADM) approvals have been obtained, as applicable.

A site-specific list of facility contacts will be developed and maintained during the life of the project.

8A.1.4.2 Volume Calculations

Volumes will be calculated for specific abandonment wellbore environment based on desired plug diameter and length required. Volume calculations are the same for plug and abandonment during construction and post-injection.

- 1) Identify the following based on the geology and hole conditions:
 - a. Length of the cement plug required.
 - b. required setting depth of base of plug.
 - c. Volume of spacer to be pumped ahead of the slurry.
- 2) Determine the following:
 - a. Number of sacks of cement required.
 - b. Volume of spacer to be pumped behind the slurry to balance the plug.
 - c. Plug length before the pipe is withdrawn.
 - d. Length of mud freefall in drill pipe.
 - e. Displacement volume required to spot the plug.

8A.1.4.3 Plugging and Abandonment Procedure for “During Construction” Scenario:

Pumping the Cement Job

- 1. Trip in Hole (TIH) to the desired depth (drill pipe tags the base of the desired plug depth).
- 2. Shut down circulating trip tank on wellbore.
- 3. Break circulation and condition mud as required. Circulate at least until the pit levels stabilize.
- 4. Mix and pump cement and spacers.
- 5. Displace with the predetermined mud volume.

6. Shut down cementing unit and allow mud to freefall.
7. Near the end of the freefall, begin pulling out. Check to verify if we are pulling dry or wet. Slowly pull the drill string out of the plug and continue trip out of hole (TOH) until 300 ft +/- above the top of the plug. Slowly pump 5-10 bbls to clear the drill pipe.
8. Waiting on cement (WOC) minimum 12 hours, and TIH to tag the plug. If the plug will hold 5-10K lbs weight, pull up, circulate 1-2 stands above and continue with next plug.
9. After placing all plugs, pull out of hole (POOH) laying down all drill pipe.
10. Cut off all casings below the plow line (or per local, state or regulatory guidelines), dump 2-5 sacks of neat cement, and weld plate on top of casing stub. Place marker if required.
11. After rig is released, restore site to original condition as possible or per local, state or federal guidelines.
12. Complete plugging forms and send in with charts and all lab information to the regulatory agency as required by permit. Plugging report shall be certified as accurate by ADM and plugging contractor, and shall be submitted within 60 days after plugging is completed.

8A.1.4.4 Plugging and Abandonment Procedure for “End of Project” Scenario:

1. Notify the regulatory agency at least 60 days before commencing operations and provide updated plugging plan, if applicable.
2. Move-in (MI) Rig onto CCS #2 and rig up (RU). All CO₂ pipelines will be marked and noted with rig supervisor prior to MI.
3. Conduct and document a safety meeting.
4. Open up all valves on the vertical run of the tree and check pressures.
5. Test the pump and line to 2,500 psi. Fill casing with kill weight brine (9.5 ppg). Bleeding off occasionally may be necessary to remove all air from the system. Test casing annulus to 1000 psi. If there is pressure remaining on tubing rig to pump down tubing and inject two tubing volumes of kill weight brine. Monitor tubing and casing pressure for 1 hour. If both casing and tubing are dead then nipple up blowout preventers (NU BOP's). Monitor casing and tubing pressures.
6. If the well is not dead or the pressure cannot be bled off of tubing, rig up (RU) slickline and set plug in lower profile nipple below packer. Circulate tubing and annulus with kill weight fluid until well is dead. After well is dead, ND tree. NU BOP's and perform a function test. BOP's should have appropriate sized single pipe rams on top and blind rams in the bottom ram for tubing. Test pipe rams and blind rams to 250 psi low, 3,000 psi high. Test annular preventer to 250 psi low and 3,000 psi high. Test all TIW's,

IBOP's choke and kill lines, and choke manifold to 250 psi low and 3,000 psi high. NOTE: Make sure casing valve is open during all BOP tests. After testing BOPs pick up tubing string and unlatch seal assembly from seal bore. Rig slick line and lubricator back to well and remove X- plug from well. Rig to pump via lubricator and circulate until well is dead.

7. POOH with tubing laying it down. NOTE: Ensure that the well is over-balanced so there is no backflow due to formation pressure and there are at least 2 well control barriers in place at all times.

Contingency: If unable to pull seal assembly, RU electric line and make cut on tubing string just above packer. Note: Cut must be made above packer at least 5-10 ft MD.

8. If successful pulling seal assembly, then pick up workstring and TIH with Quantum packer retrieving tools. If tubing was cut in previous step then skip this step. Latch onto Quantum packer and pull out of hole laying down same. If unable to pull the Quantum packer, pull the work string out of hole and proceed to next step. Assuming the tubing can be pulled with the packer without issues, run CBL, casing caliper, RST and/ or USIT to assist in assessing wellbore mechanical integrity leakage around the wellbore above the caprock. If problems are noted, update cement remediation plan (if needed) and execute prior to plugging operations. TIH with work string to TD. Keep the hole full at all times. Circulate the well and prepare for cement plugging operations.
9. The lower section of the well will be plugged using CO₂ resistant cement from TD around 7000ft to around 1000ft above the top of the Eau Claire Formation (to approximately 4000 ft). This will be accomplished by placing plugs in 500 ft increments. Using a density of 15.9 ppg slurry with a yield of 1.11 cu ft/sk, approximately 1333 sacks of cement will be required. Actual cement volume will depend upon actual weight of the casing within the plugged zone as well as the length of plug set. This will require at least six plugs of 500 feet in length. No more than two plugs will be set before cement is allowed to set and plugs verified by setting work string weight down onto the plug. (Calculations: Assume 47 lb/ft casing for this interval 3000ft x .4110 cu ft/ft x 1.20/ 1.11 cu ft/sk = 1333 sacks)
10. Circulate the well and ensure it is in balance. Place tubing just above cement top from previous day. Mix and spot 500 ft balanced plug in 9 5/8 inch casing (approximately 180 sacks Class A/H mixed at 15.9 ppg with yield 1.18 cu ft/sk)). Pull out of plug and reverse circulate tubing. Repeat this operation until a total of 8 plugs have been set. If plugs are well balanced then the reverse circulation step can be omitted until after each third plug. Lay down work string while pulling from well. If rig is working daylight only then pull 10 stands and rack back in derrick and reverse tubing before shutting down for night. After waiting overnight, trip back in hole and tag plug and continue. After ten plugs have been set pull tubing from well and shut in for 12 hours. Trip in hole with tubing and tag cement top. Calculate volume for final plug. Pull tubing back out of well. Nipple down BOPs and cut all casing strings below plow line (min 3 feet below ground level or per local policies/standards and ADM requirements). Trip in well and set final cement plug.

Total of approximately 1443 sacks total cement used in all remaining plugs above 4000 feet. Lay down all work string, etc. Rig down all equipment and move out. Clean cellar to where a plate can be welded with well name onto lowest casing string at 3 feet, or as per permitting agency directive. (Calculations assume 40#/ft casing and no excess because this section is inside the intermediate casing $4000 \text{ ft} \times .4257 \text{ cu ft/ft} / 1.18 \text{ cu ft/sk} = 1443$ sacks

11. Complete plugging forms and send in with charts and all lab information to the regulatory agency as required by permit. Plugging report shall be certified as accurate by ADM and plugging contractor, and shall be submitted within 60 days after plugging is completed.